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AVHRR–Based Polar Pathfinder Products: Evaluation, Enhancement and Transition to MODIS

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Interim Report – 2nd year

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1. OVERVIEW

The AVHRR–Based Polar Pathfinder (APP) products include calibrated AVHRR channel data, surface temperatures, albedo, satellite scan and solar geometries, and cloud mask, all composited into twice–per–day images, and daily averaged fields of sea ice motion, for regions poleward of 50^0 Latitude.

Our general goals under this grant:

- Quantify the APP accuracy and sources of error by comparing Pathfinder products with field measurements
- Determine the consistency of mean fields and trends in comparison with longer time series of available station data and forecast model output
- Investigate the consistency of the products between the different AVHRR instruments over the 1982–present period of the NOAA program
- Compare and annual cycle of the APP products with MODIS to establish a baseline for extending Pathfinder–type products into the new ESE period

2. APP PRODUCTS

2.1 Albedo Calculations

In year one, preliminary comparisons were done between the APP products and in–situ data. Differences were found primarily in the albedo products. When the algorithms were developed, models had been derived from a limited amount of field measurements. These measurements were found not to be representative of the much wider coverage of the APP products.

Changes were made to the algorithms used to generate broad–band albedo from the AVHRR channel data. The final APP products reflect these changes.

2.2 Thermal Calibrations

When comparisons were first done between the APP products and data from the Surface Heat Balance of the Arctic (SHEBA) experiment, problems were found in the calibrations of the AVHRR thermal channels. An error in the calibration code was found and corrected.

At this time, a review of all the calibrations used in the AVHRR processing was done. The calibration of the AVHRR followed the original methods described in the NOAA/NESDIS manuals. These methods were not consistent between all the satellites. As newer satellites were launched, techniques changed based on previous experience and scientific requirements. The primary requirement had been for sea surface temperature, a much narrower temperature range than that required for the APP products.

Since the APP processing began, a consistent method had been proposed that is common to all the NOAA AVHRR instruments. This new method also is more accurate over the full range of temperatures needed for the APP. This new calibration scheme was implemented by the APP program. Because much of the data had already been partially processed, a set of look–up values were generated to correct already processed data. This correction appears to bring the brightness temperatures to within 0.1 degrees of the values that would be provided by the newer calibration methods. All new processing of the AVHRR data would be done with the new methods, and already processed data would be corrected using the look–up tables. These look–up tables are non–linear, especially near the lower ends of the APP temperature range. This is particularly important for the polar regions.

The results from the SHEBA comparisons that initiated this calibration change was from the newer NOAA satellite NOAA–14. The corrections for this satellite are much larger, due to the error in the program. It may be necessary to redo the processing from this satellite.

For a more detailed discussion an appendix is attached. The attachment can also be found on our web site:
http://polarbear.colorado.edu/APP–calibration/calib.html

2.3 Cloud Masking Methods

When the APP processing began, cloud masking methods had not been fully investigated. During the APP program, several methods were tested. During the past year, a technique was implemented based on several methods. A combination of temporal and spatial statistical techniques are used to detect clouds and generate a mask. Cloud masking of satellite data may be the hardest product to verify. In–situ cloud cover data is mostly from subjective estimates of cloud fraction. An even larger problem is the time of the ground observations and the time of the satellite overpass. Slight differences in time are very important since the cloud cover is highly variable in time and space.

From examining the cloud masks and the AVHRR channel data, an rough estimate of the accuracy may be about 90–95. This estimate applies to both daytime and nighttime APP products.

2.4 Final APP Products

Because of the above problems and investigations the final delivery of the APP products was delayed. A final processing is being applied to the APP products before delivery to NSIDC. This step includes correction of the thermal calibration, generation of the surface albedo and temperature and cloud mask, using the most current algorithms.

3. COMPARISONS OF APP PRODUCTS AND FIELD DATA

3.1 South Pole Observatory

In 1995, a set of temperature data was obtained from sled mounted instruments for use in comparisons with the APP products. Over a 7 day period, measurements were taken around a 500 meter triangular area.

The comparisons with the APP products are shown in figures 1 and 2. Figure 1 is a plot of the in-situ temperatures versus the APP surface temperature. The agreement is good except for days June 28 and 29 when some thin cloud was present.

Figure 2 is a finer resolution plot for day 24 only. The mean temperature for the APP surface temperature was -38.15 C with the mean in-situ temperature of \38.25 C. The surface temperature from satellite compares very well with field measurements.

3.2 Greenland

A network of stations on Greenland continually take measurements of temperature and albedo. One year of 1997 APP products were compared with these in-situ readings. Before the revision of the albedo algorithms previously mentioned, albedo values were often above 100%. After the changes to the methods, the albedo values are much more reasonable. However, there is some variability that seems to be associated with the satellite scan angle that is still unexplained. Figure 3 is a comparison showing 12 stations on Greenland. The variability is present at all stations.

3.3 SHEBA

In 1997 and 1998, measurements were taken at the SHEBA site in the Beaufort Sea. Comparisons were done with both surface albedo and temperature. Figure 4 is an inter-comparison of the temperature and figure 5 is of albedo. Both show excellent agreement of the ground based measurements and satellite derived values.

4. DATA PRESENTED AT AMS MEETING

A collaboration between the Polar Pathfinders produced a data sampler covering 2 years of data. Examples of data products from each pathfinder was included. Also included was a "3-D" cube of data at a common resolution of 100km.

5. YEAR THREE GOALS

5.1 If possible, compare APP type products with similar imagery from ESE data.

5.2 Continue comparisons with ground based measurements as complete 16 year APP products become available.

5.3 As the full set of APP products is available, look for any differences in the time series due to changes in the satellites.

5.4 Compute mean values for different parameters from the APP products and compare with long term climatologies from in-situ values.

5.5 Document any errors, special cases, inconsistencies, and accuracies in the APP data sets.

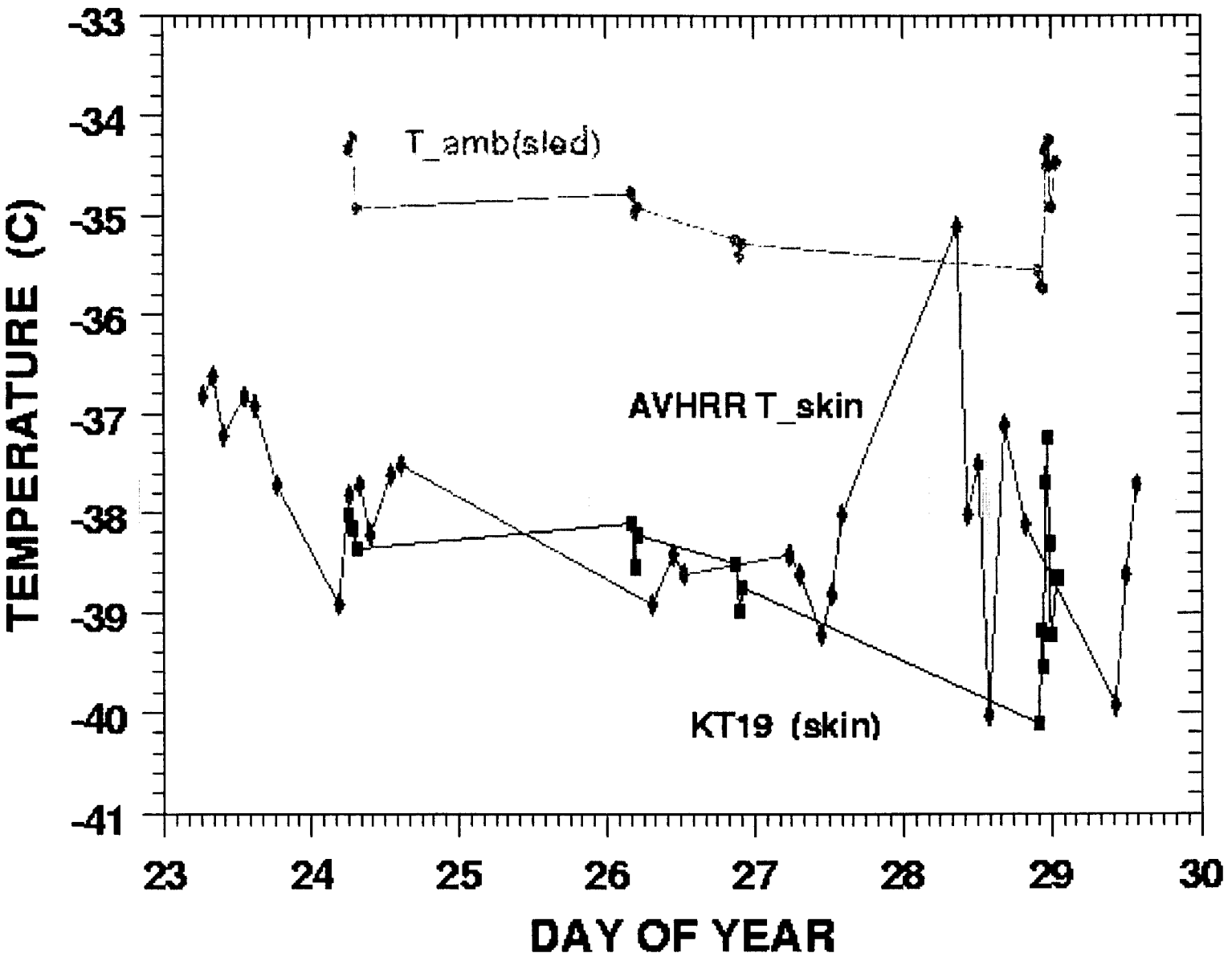
SPO JAN.1995 SLED EXPERIMENT (6/29/99)
T_amb(sled)
AVHRR T_skin
KT19 (skin)
TEMPERATURE (C)
-33
-34
-35
-36
-37
-38
-39
-40
-41
23
24
25
26
27
28
29
30
DAY OF YEAR

Fig 1

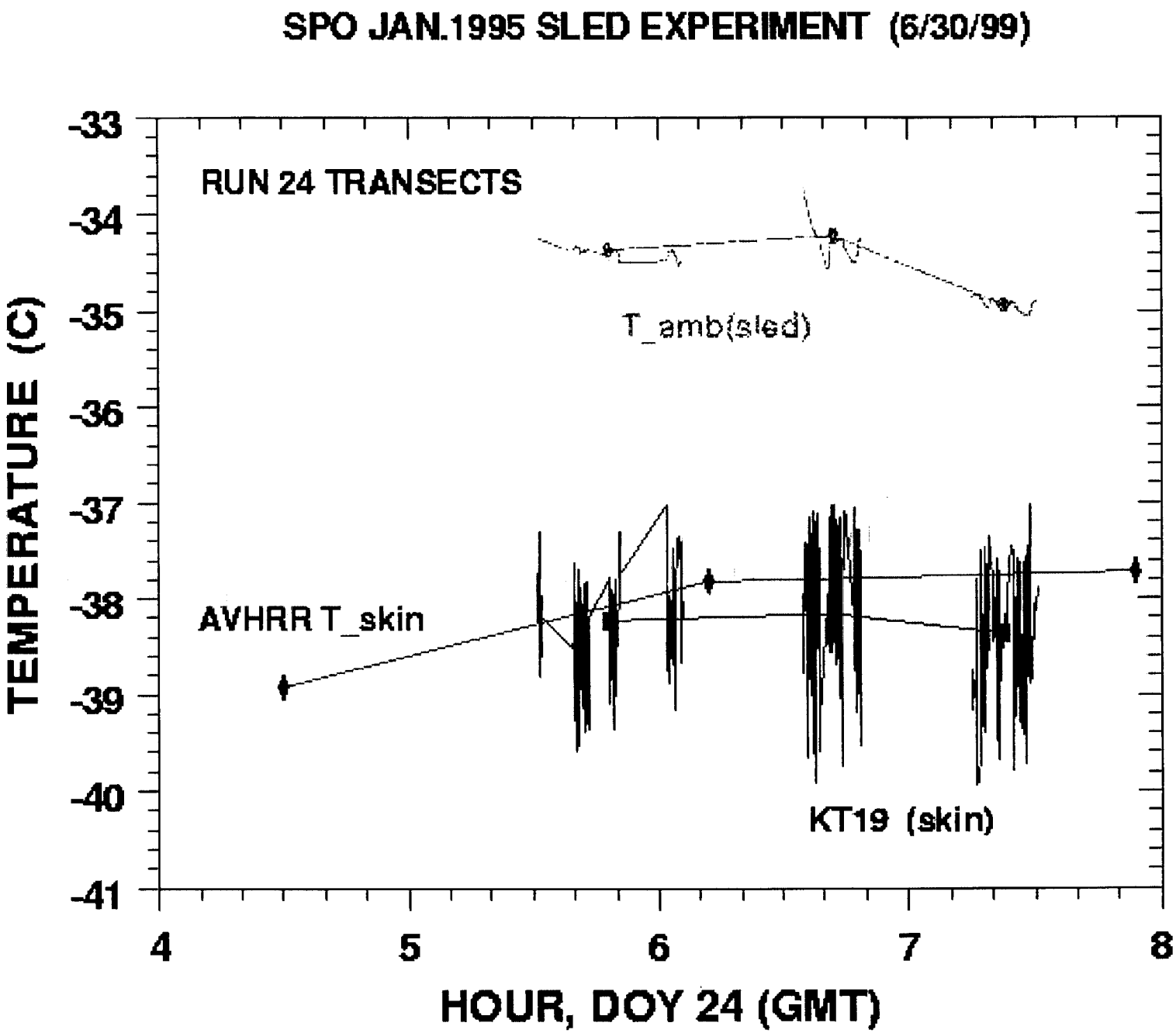
SPO JAN.1995 SLED EXPERIMENT (6/30/99)
RUN 24 TRANSECTS
T_amb(sled)
AVHRR T_skin
KT19 (skin)
TEMPERATURE (C)
-33
-34
-35
-36
-37
-38
-39
-40
-41
4
5
6
7
8
HOUR, DOY 24 (GMT)

Fig 2

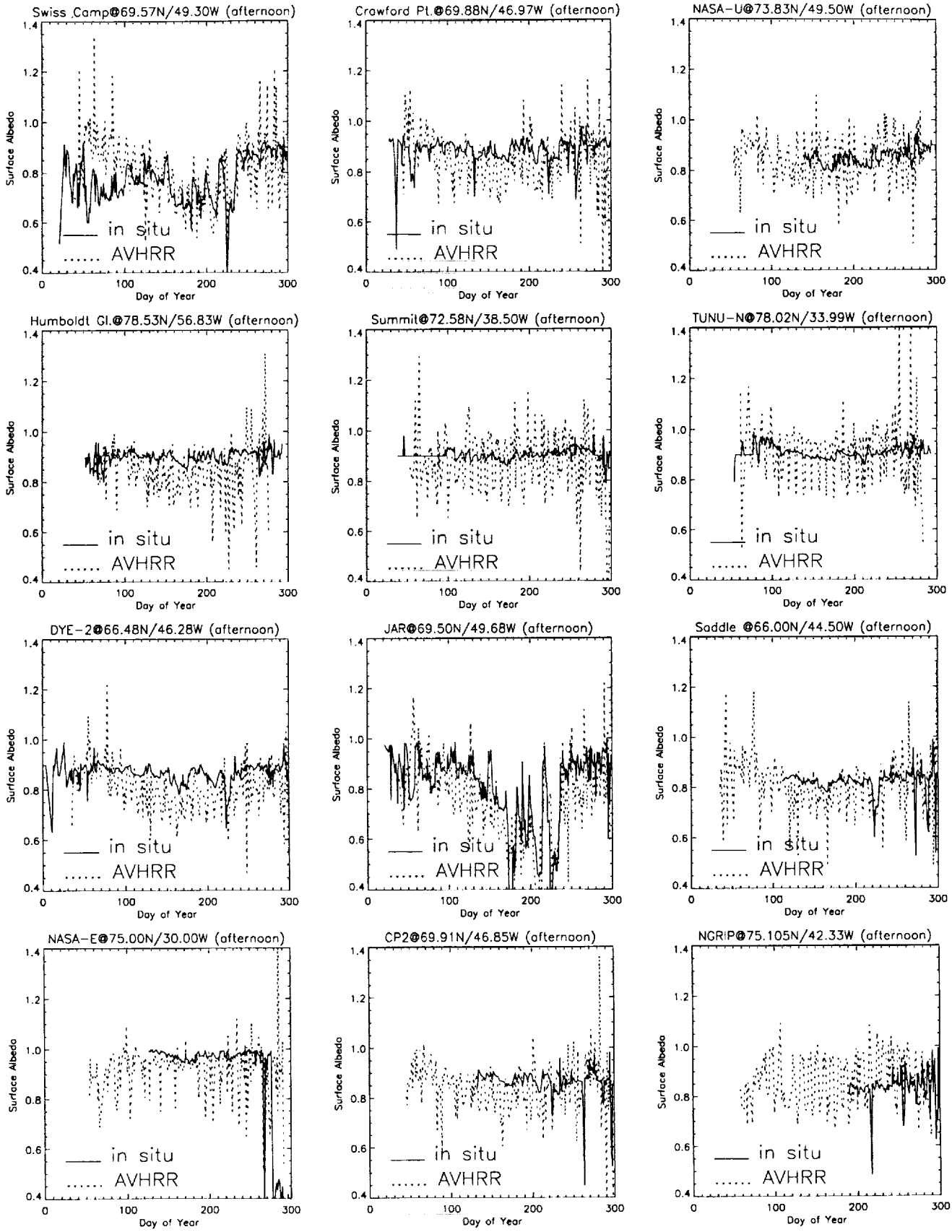
Swiss Camp@69.57N/49.30W (afternoon)
Crawford Pt.@69.88N/46.97W (afternoon)
NASA-U@73.83N/49.50W (afternoon)
Humboldt Gl.@78.53N/56.83W (afternoon)
Summit@72.58N/38.50W (afternoon)
TUNU-N@78.02N/33.99W (afternoon)
DYE-2@66.48N/46.28W (afternoon)
JAR@69.50N/49.68W (afternoon)
Saddle @66.00N/44.50W (afternoon)
NASA-E@75.00N/30.00W (afternoon)
CP2@69.91N/46.85W (afternoon)
NGRIP@75.105N/42.33W (afternoon)
Surface Albedo
Day of Year
in situ
AVHRR

Fig 3

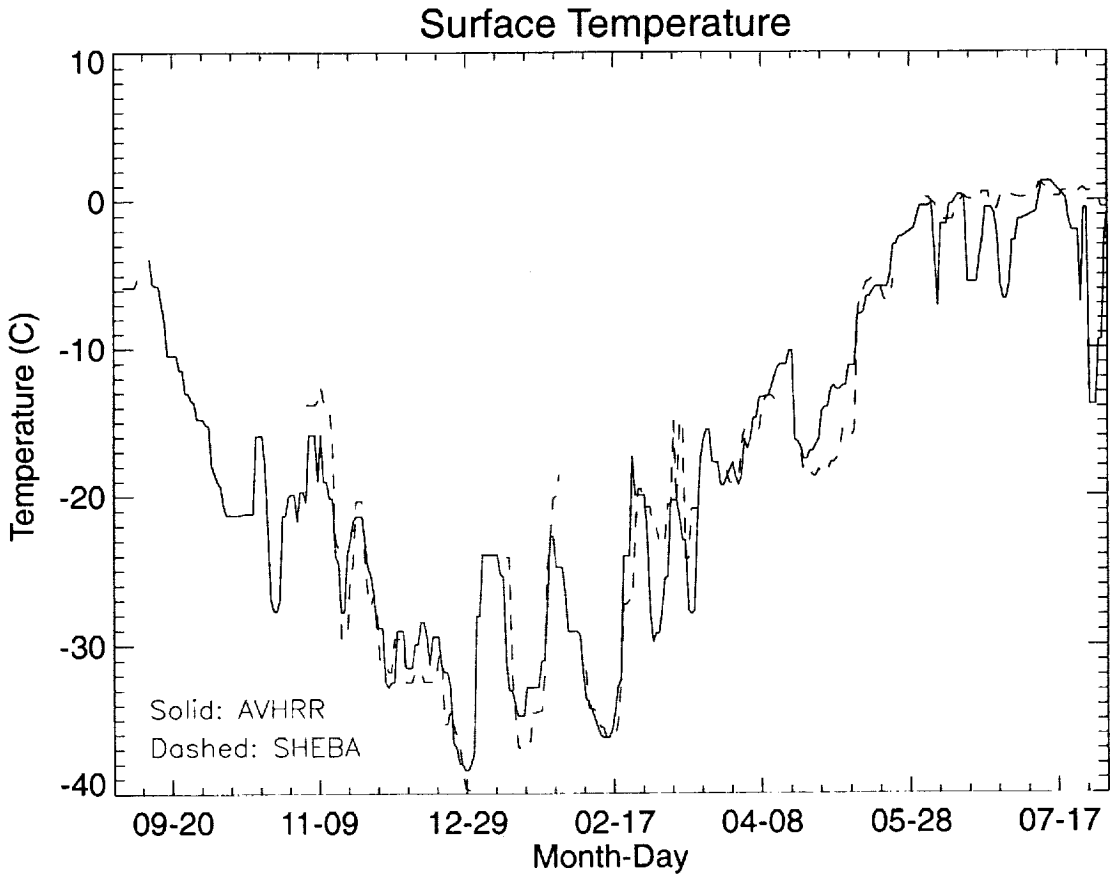
Surface Temperature
10
0
-10
-20
-30
-40
Temperature (C)
Solid: AVHRR
Dashed: SHEBA
09-20
11-09
12-29
02-17
04-08
05-28
07-17
Month-Day

Fig 4

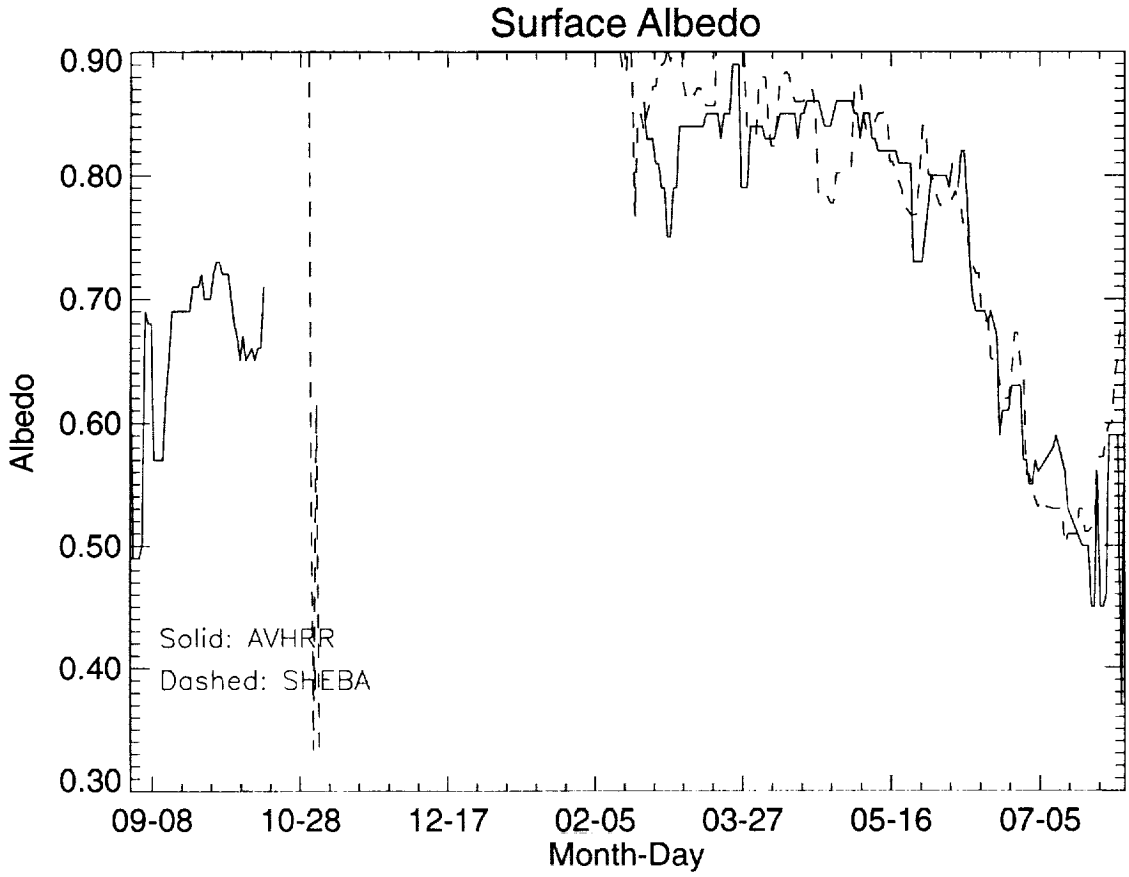
Surface Albedo
0.90
0.80
0.70
0.60
0.50
0.40
0.30
Albedo
Solid: AVHRR
Dashed: SHEBA
09-08
10-28
12-17
02-05
03-27
05-16
07-05
Month-Day

Fig 5